Time Domain Modal Parameter Estimation

Project Number: 97-15

Investigator: A. Patterson/ED73

Purpose

A time domain parameter estimation method has been developed to augment current frequency domain-based parameter estimation methods used in modal test applications. This effort extends the time domain estimation algorithm by admitting nonlinear models into the fitting process and by using a genetic algorithm (GA) to optimize the model's parameters.

Background

Modal testing is used to experimentally determine the characteristics of structural systems. The experimentally derived structural parameters are used to tune and verify analytical models. Standard modal test techniques use data generated by random and burst-random inputs applied through electrodynamic shakers and measured with piezo-electric load cells. The response outputs are measured by accelerometers mounted at various locations on the structure. The current modal test methodology to derive the structural characteristics is based on frequency domain methods which use sampled frequency spectra from windowed, fast Fourier transforms (FFT) of the inputs and responses to compute frequency response functions (FRF). Curve fitting is applied to the FRF's to generate analytic expressions for which the modal parameters (frequency, damping, and mode shape) are estimated. Implicit in the FFT is the requirement that the data operated on be periodic within the sample interval on which the FFT is computed. This demonstrates the need for the windowing operation on the measured quantities since, in general, the measured data is not periodic within the FFT envelope. The windowing operation introduces bias errors in the parameter estimates and also filters out information from the data since the tail of the data block is driven to zero. This problem is overcome by overlapping data blocks and averaging to produce cleaner spectral density estimates. The FRF's calculated from these spectral density estimates still exhibit some noisy characteristics. This noise characteristic is a consequence of using the sampled spectral density as an estimate of the true, continuous spectral density. As noted by Kendall,[1] the sampled covariance is a very poor estimator of the true, continuous covariance, and the sampled spectral density is computed from the sampled covariance which produced the noisy spectral density estimate. Based on these theoretical limitations of the frequency based methods, work was initiated to pursue the time domain methods.

Approach

- Modify the previously developed time domain parameter identification code to incorporate the GA as the optimization method in fitting the model parameters.

- Perform a series of trade studies to optimize the type of GA to implement, i.e., model parameters encoded as binary elements or real, floating point elements, and traditional GA mutation versus a hybrid technique using a local search via simulated annealing.

- Exercise the new code with theoretically derived data to verify that the identified parameters are accurate.

- Once the code is verified with the theoretical data, apply the algorithm to experimentally derived dynamic data and compare the results with the standard frequency domain methods.

Accomplishments

A literature search on GA's has been completed. A GA in the form of a C^{++} library has been obtained and the trade studies have been initiated to optimize the various elements of the GA for the application of system identification. The theoretically derived data to verify the modified time domain code has been generated.

Planned Future Work

The trade studies will be completed. Based on the trade study results, the appropriate GA will be incorporated into the existing time domain code and the theoretically derived data will be processed to determine the modal parameters and verify the code. With the code verified from the theoretical data, experimental data will then be processed and compared with the standard frequency domain codes used in modal testing.

Funding Summary ($k)

	FY97	FY98	Total
Authorized FY97	1	0	1
Obligated	1	0	1
Unprocessed	0	0	0

Status of Investigation

Project approval—January 23, 1997

Estimated completion—December 31, 1998

[1]Kendal, M.G.: "On the Analysis of Oscillatory Time Series," *Royal Statistical Soc.*, Vol. 108, p. 93, 1945.